

PHYSICS 222, Fall 1994
Final Exam, December 13, 1994, 4:30 – 6:30 pm
VERSION A

Instructions:

1. Check that your multiple choice answer sheet (“bubble sheet”) is marked ”A”. If it not so marked, call one of the instructors. Also check the version on pages 5 and 9.
2. The first ten questions of this exam (numbered from 37 to 46) are about the laboratory part of this course. Each correct answer is **worth 2 points**.
3. The next eleven questions (numbered from 47 to 57) are about recent material (thermodynamics). Questions 58 through 68 are about material covered in earlier exams. Correct answers to questions 47 through 68 are **worth 4 points each**.
4. Please note that questions 57 and 68 are bonus questions.
5. There are no write-up problems in this exam.
6. This exam has 14 pages numbered from 1 to 14. All sheets are printed on both sides. If you are missing one of the pages, call one of the instructors.
7. In marking the multiple choice answer sheet use a number 2 pencil. Do NOT use ink. If you did not bring a pencil, ask for one. Fill in the appropriate circles completely. If you need to change an entry, you must first completely erase your previous entry.
8. Make sure that your name, student identification number, and section number are filled in at the appropriate places on the computer answer sheet.
9. You will need a calculator for some of the questions. If you did not bring a calculator, or if your calculator stops working during the exam, call one of the instructors. We have a limited number of calculators available.
10. Ask one of the instructors for assistance, if you have additional questions.
11. Good luck and have a good semester break !!!

VERSION A

47. The exercising component of a weight-loss program can be described by the following symbol in the first law of thermodynamics:
- (A) The heat Q supplied to the thermodynamical system.
 - (B) The internal energy U of the thermodynamical system.
 - (C) The internal energy change ΔU of the thermodynamical system.
 - (D) The work W done by the thermodynamical system.
 - (E) The temperature T of the thermodynamical system.

The following information is for the next **five** questions (48 – 52): One mole of helium (which we treat as an ideal gas) at 0°C (273 K) and a pressure of 101 kPa is **compressed** quasistatically to a pressure of 505 kPa. The molar specific heat at constant volume of helium is $12.5 \text{ J/mol}\cdot\text{K}$. The universal gas constant is $8.314 \text{ J/mol}\cdot\text{K}$. The molecular mass of helium is 4 g/mol . Its density (under normal conditions) is 0.18 kg/m^3 .

48. Assume the gas is compressed **adiabatically**. Which of the following statements is **true** ?
- (A) The temperature of the gas increases.
 - (B) The work done by the gas is positive.
 - (C) The temperature of the gas remains the same.
 - (D) The temperature of the gas decreases.
 - (E) The gas loses heat to its environment.
49. If the helium gas is compressed **isothermally**, the final volume of the compressed gas is
- (A) 22.4 l.
 - (B) 11.2 l.
 - (C) 8.53 l.
 - (D) 4.48 l.
 - (E) 7.07 l.

50. If the gas is compressed **isothermally**, the heat released by the gas to its environment is

- (A) 3653 J.
- (B) 2617 J.
- (C) 1792 J.
- (D) 2240 J
- (E) No heat is released, since the process is isothermal.

51. If the helium gas is compressed **adiabatically**, the final volume of the compressed gas is

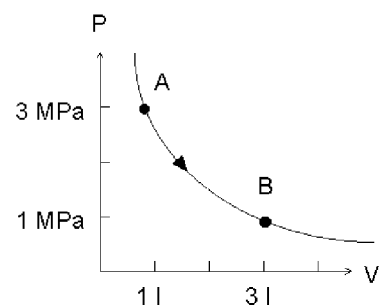
- (A) 22.4 l.
- (B) 11.2 l.
- (C) 8.53 l.
- (D) 4.48 l.
- (E) 7.07 l.

52. The rms velocity of the helium molecules is 1305 m/s before compression. If the helium gas is compressed **isothermally**, the rms velocity of the helium molecules after compression is

- (A) 1305 m/s.
- (B) 6524 m/s.
- (C) 1928 m/s.
- (D) 261 m/s.
- (E) 583.6 m/s.

53. One mole of an ideal gas is taken from point A to point B at a constant temperature of 77°C. Which entry in the table below is correct for this process?

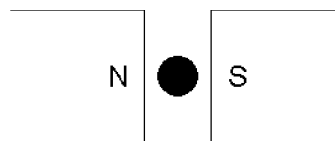
- | | | |
|----------------------|-----------------|-----------------------|
| (A) $W=700$ J, | (B) $W=700$ J, | (C) $W=3200$ J, |
| $Q=0,$ | $Q = -700$ J, | $Q=0,$ |
| $\Delta U = -700$ J. | $\Delta U=0.$ | $\Delta U = -3200$ J. |
| (D) $W = -3200$ J, | (E) $W=3200$ J, | |
| $Q=3200$ J, | $Q=3200$ J, | |
| $\Delta U=0.$ | $\Delta U=0.$ | |



54. Which of the following statements is **correct**? By the second law of thermodynamics,
- (A) all heat engines have the same efficiency.
 - (B) all reversible heat engines have the same efficiency.
 - (C) the efficiency of a heat engine depends only on the quality of the fuel.
 - (D) the efficiency of a Carnot engine depends only on the temperatures of the two reservoirs.
 - (E) all Carnot engines theoretically have 100% efficiency.
55. The rate of heat flow through a slab does **NOT** depend upon the
- (A) temperature difference between the opposite faces of the slab.
 - (B) thermal conductivity of the slab
 - (C) slab thickness.
 - (D) cross-sectional area of the slab.
 - (E) specific heat of the slab.
56. A Carnot cycle heat engine operates between 227°C and 127°C . Its efficiency is
- (A) 20%.
 - (B) 25%.
 - (C) 44%.
 - (D) 79%.
 - (E) 100%.
57. What is the minimum amount of work that must be done to extract 400 J of heat from a massive object at 0°C to a warm reservoir at a temperature of 20°C ?
- (A) 25.3 J.
 - (B) 27.3 J.
 - (C) 29.3 J.
 - (D) 54.6 J.
 - (E) 546 J.
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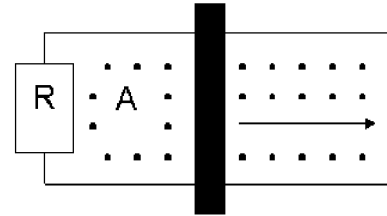
58. The diagram shows a straight wire carrying a flow of electrons out of the page. The wire is between the poles of a permanent magnet. The direction of the magnetic force exerted on the wire is:

- (A) upward.
- (B) downward.
- (C) to the left.
- (D) to the right.
- (E) into the page.



59. The figure shows a conducting bar moving to the right at constant speed on two conducting rails. A uniform magnetic field directed out of the page exists in region A. The direction of the induced current in the circuit will be

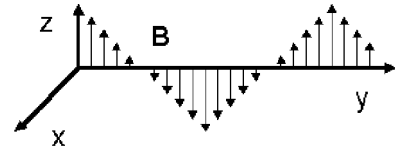
- (A) clockwise.
- (B) counterclockwise.
- (C) into the page.
- (D) out of the page.
- (E) No induced current is present since the bar has a constant velocity.



60. An oscillator producing 10 volts (rms) at 60 Hz is connected in series with a $50\ \Omega$ resistor, a 400 mH inductor, and a $200\ \mu\text{F}$ capacitor. The rms current is:
- (A) 6.27 mA
 - (B) 62.7 mA
 - (C) 128.8 mA
 - (D) 68.3 mA
 - (E) 6.83 mA
61. A loudspeaker is adjusted to cause a pipe to resonate in its fundamental mode at 500 Hz. The pipe is 34 cm long, open at both ends and the speed of sound in the air inside the pipe is 340 m/s. What happens, if one of the ends of the pipe is closed ?
- (A) The fundamental frequency is unchanged (remains at 500 Hz).
 - (B) The new fundamental frequency is 250 Hz.
 - (C) The new fundamental frequency is 1000 Hz.
 - (D) The new fundamental frequency is about 700 Hz.
 - (E) The new fundamental frequency is about 350 Hz.
62. Two trains travelling in opposite directions are approaching each other on adjacent parallel tracks, travelling at speeds of 100 km/h and 120 km/h. The faster train is blowing its whistle with a frequency of 400 Hz. How will the frequency heard by the driver of the slower train change, as the two trains pass each other. The speed of sound in still air is 330 m/s.
- (A) From 400 Hz to 333 Hz.
 - (B) From 482 Hz to 333 Hz.
 - (C) From 333 Hz to 482 Hz.
 - (D) From 363 Hz to 433 Hz.
 - (E) From 445 Hz to 366 Hz.

63. The electric field for a plane electromagnetic wave traveling in the $+y$ direction is shown in the figure. Consider a point where the magnetic field \mathbf{B} is in the $+z$ direction. The electric field \mathbf{E} is

- (A) in the $+x$ direction and in phase with \mathbf{B} .
- (B) in the $-x$ direction and in phase with \mathbf{B} .
- (C) in the $+x$ direction and lags \mathbf{B} by $\pi/2$.
- (D) in the $+z$ direction and in phase with \mathbf{B} .
- (E) in the $+z$ direction and lags by $\pi/2$.

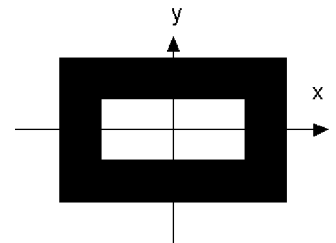


64. A thin ($t=825$ nm) uniform layer of clear beer ($n=1.28$) covers a flat plastic bar table ($n=1.21$). For which of the following wavelengths from an overhead lamp would there be an interference **maximum** in the light reflected normal to the surface.

- (A) 704 nm
- (B) 550 nm
- (C) 528 nm
- (D) 603 nm
- (E) 660 nm

65. Monochromatic light traveling along the z -direction is incident on a piece of cardboard with a narrow rectangular slit cut out of it, as shown in the figure. The resulting two-dimensional diffraction pattern is projected on a flat screen (oriented perpendicular to the z -axis) behind the cardboard slit. Which of the following statements about the diffraction pattern is **correct**?

- (A) The distance between the bright fringes is greater in the y -direction than in the x -direction.
- (B) The distance between the bright fringes is greater in the x -direction than in the y -direction.
- (C) The distance between the bright fringes will be the same in either direction since monochromatic light is being used.
- (D) There won't be a diffraction pattern present because the slit has a finite width.
- (E) None of the above statements are correct for the conditions given.



66. Light of wavelength 310 nm falls on a metallic surface made of the element lithium. The work function of lithium is 2.3 eV. Find the de Broglie wavelength of the fastest emitted photoelectrons.
- (A) 310 nm.
 - (B) 23.2 nm.
 - (C) 3.16 nm.
 - (D) 0.94 nm.
 - (E) 0.024 nm.
67. A singly ionized helium atom He^+ has a hydrogen-like spectrum. It makes a transition from the Bohr state with $n=3$ to the Bohr state with $n=2$. Which of the following statements is correct?
- (A) A photon of wavelength 660 nm is emitted.
 - (B) A photon of wavelength 164 nm is emitted.
 - (C) A photon of wavelength 164 nm is absorbed.
 - (D) A photon of wavelength 660 nm is absorbed.
 - (E) None of these statements are correct.
68. A small object is placed 10 cm in front of a convex lens with a focal length of magnitude 20 cm. Which of the following statements correctly describes the position and characteristics of the image.
- (A) The image is formed 20 cm behind the lens and is reduced.
 - (B) The image is formed 20 cm behind the lens and is enlarged.
 - (C) The image is formed 20 cm in front of the lens and is enlarged.
 - (D) The image is formed 20 cm in front of the lens and is diminished.
 - (E) The image is formed 10 cm behind the lens and is enlarged.